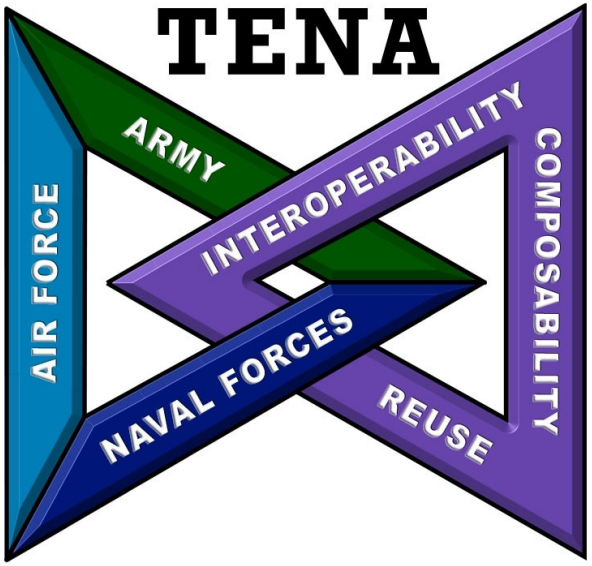


Test and Training Enabling Architecture (TENA)

The Foundation for DoD Range Interoperability

Gene Hudgins

TENA Development Lead

4 March 2003

Foundation Initiative 2010 Mission

Currently, range systems tend to be non-interoperable, "stove-pipe" systems.

The purpose of TENA is to provide the architecture and the software implementation necessary to:

- **Enable interoperability among Range systems, Facilities, Simulations, C4ISR systems in a quick, cost-efficient manner, and**
- **Foster Reuse for Range asset utilization and for future developments.**

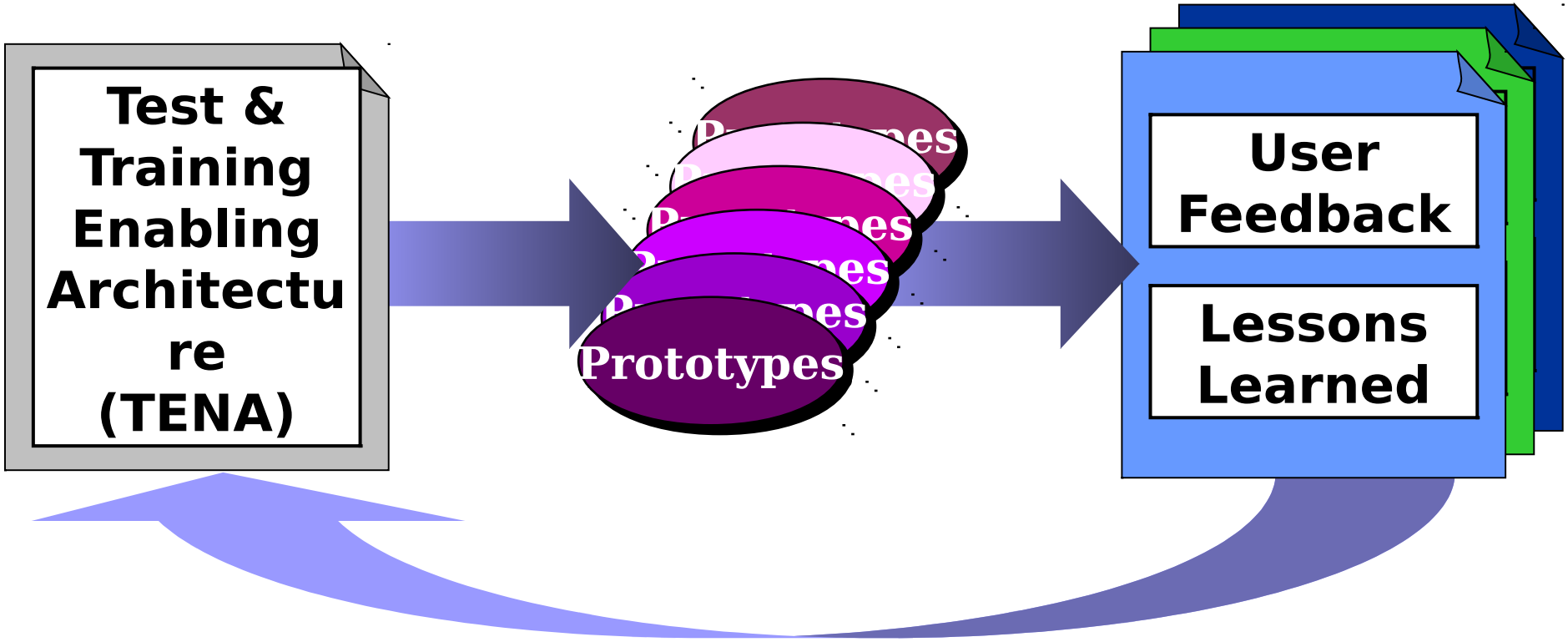
- **Support the Warfighter (Joint Vision 2010/2020)**
- **Enable Simulation-Based Acquisition**
- **Foster Test and Training Integration**
- **In the long term: SAVE MONEY!**

Lay the Foundation for Future Test and Training Range Instrumentation

Foundation Initiative 2010 Project Objectives

- **Define a common Architecture for the test/training range community – called "TENA" (Test & Training Enabling Architecture)**
  - Define a common **Object Model** to be used across the ranges
  - Define and build a common Software **Middleware** that will:
    - Use the object model
    - Enhance interoperability and reuse among the ranges
- **Common understanding of range processes – the Logical Range Concept of Operations**
- **Define and prototype common Tools to configure and conduct multi-range, synthetic test events or training exercises**
  - Create distributed, synthetic battlespaces with real weapon systems
  - Link multiple ranges together to form a larger, cohesive range
  - Enable testing, assessment, experimentation, and training of weapon system interoperability, C4ISR, and system-of-systems

Overall Development Strategy



- TENA was revised based on user feedback and lessons learned from working software prototypes
- TENA will be revised in the future based on future prototypes

TENA is based on real-world tests at real ranges

Driving Technical Requirements

1. **Interoperability**
   - The characteristic of a suite of independently-developed components, applications, or systems that implies that they can work together, as part of some business process, to achieve the goals defined by a user or users.

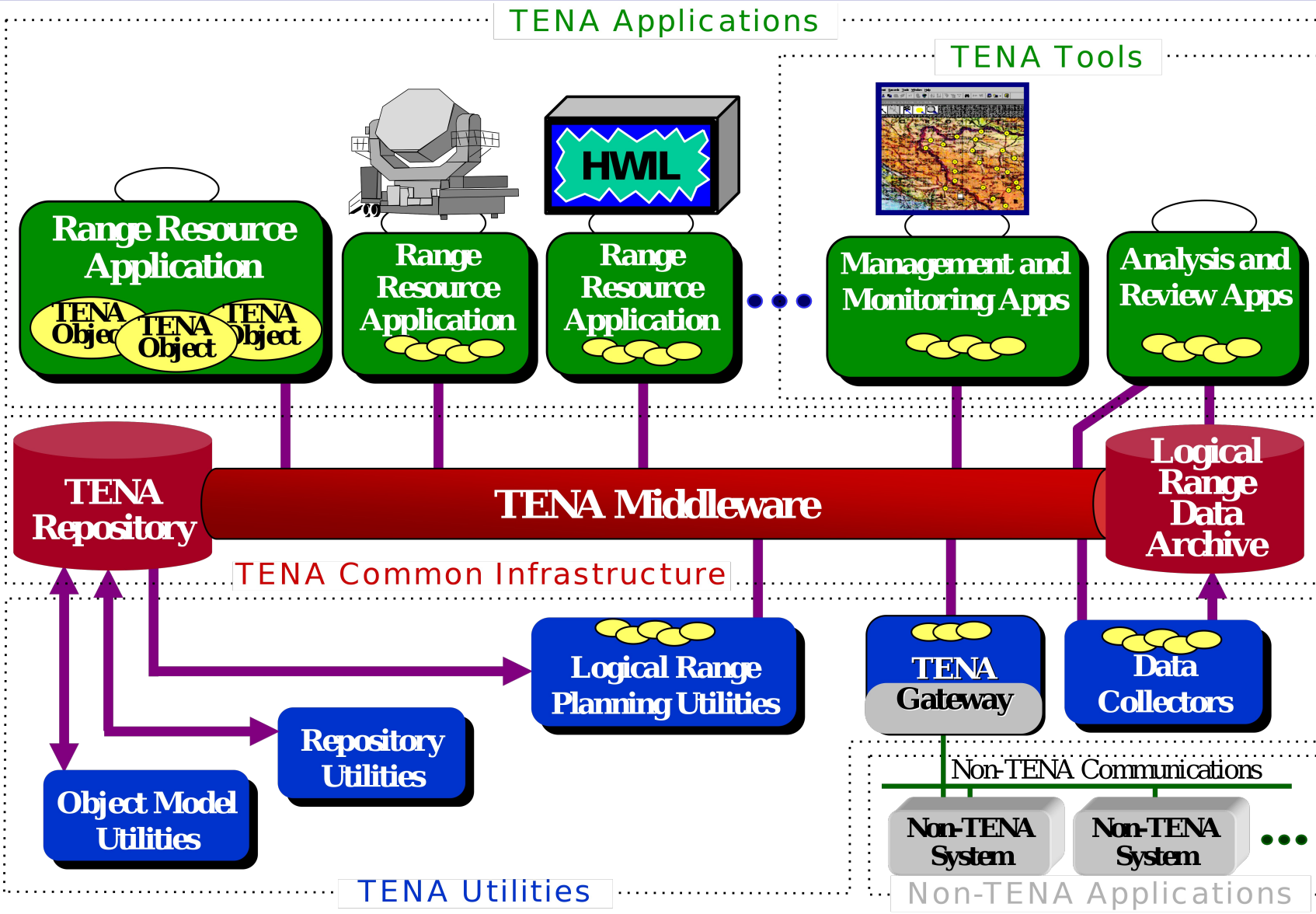
2. **Reusability**
   - The characteristic of a given component, application, or system that implies that it can be used in arrangements, configurations, or in system-of-systems beyond those for which it was originally designed.

3. **Composability**
   - The ability to rapidly assemble, initialize, test, and execute a system from members of a pool of reusable, interoperable elements.
   - Composability can occur at any scale — reusable components can be combined to create an application, reusable applications can be combined to create a system, and reusable systems can be combined to create a system-of-systems.

Achieving Interoperability, Reuse, and Composability

- **Interoperability requires:**
  - A common architecture → **TENA**
  - An ability to meaningfully communicate
    - A common language → **TENA Object Model (OM)**
    - A common communication mechanism → **TENA Middleware**
    - A physical connection between the two systems → **Network, shared memory**
  - A common context
    - A common understanding of the environment → **TENA Object Model (Environment)**
    - A common understanding of time → **TENA OM, TENA Middlewar**
    - A common technical process → **TENA Technical Process**
- **Reuse and Composability require the above, plus**
  - Well defined interfaces and functionality for the application to be reused → **Reusable Tools, Repository**

TENA Architecture Overview



Ways TENA Middleware Can Exchange Data

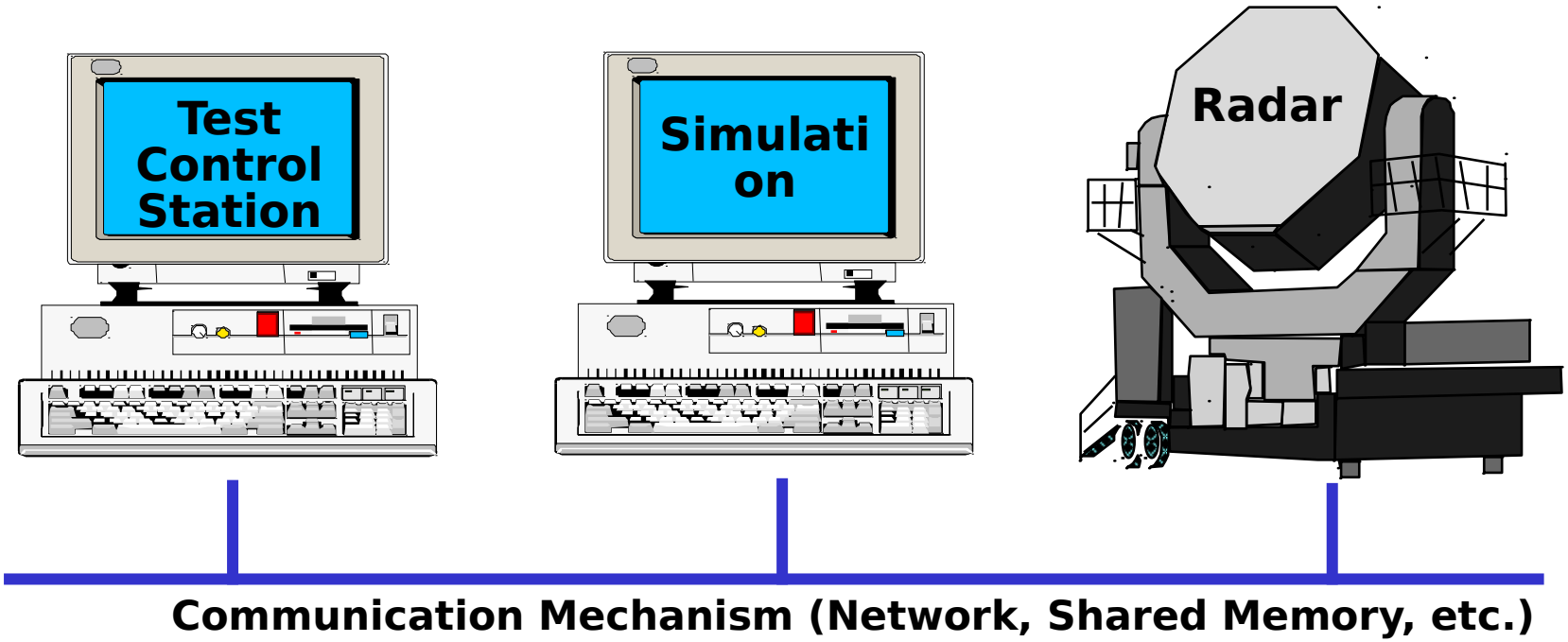
- **TENA presents to the range user a unification of several powerful inter-application communication paradigms**
  - **Publish/Subscribe**
    - Similar in effect to HLA, DIS, or other PDU-based communication systems
    - Each application publishes certain types of information (the publication state) which can be subscribed to by any other application
  - **Remote Method Invocation**
    - Similar to CORBA or Java RMI
    - Each object that is published may have methods that can be remotely invoked by other applications
  - **Messages**
    - Individual messages that can be sent from one application to one or more other applications
  - **Data Streams**
    - Native support for audio, video, and telemetry

Stateful Distributed Objects

- **An SDO is a combination of two powerful concepts:**
  - a distributed object paradigm (like the one used in CORBA)
  - a distributed publish and subscribe paradigm.
- **Benefits of this combination:**
  - A conventional distributed object-oriented system offers no direct support to the user for disseminating data from a single source to multiple destinations.
  - A conventional publish-subscribe system does not provide the abstraction of objects with a set of methods in their interface.
  - Interface to SDOs is a lot simpler and more usable than the combination of interfaces to their underlying technologies.
- **ANY APPLICATION can act as a server of some SDO objects and a client of other objects AT THE SAME TIME**
  - TENA is a **PEER-TO-PEER** Architecture

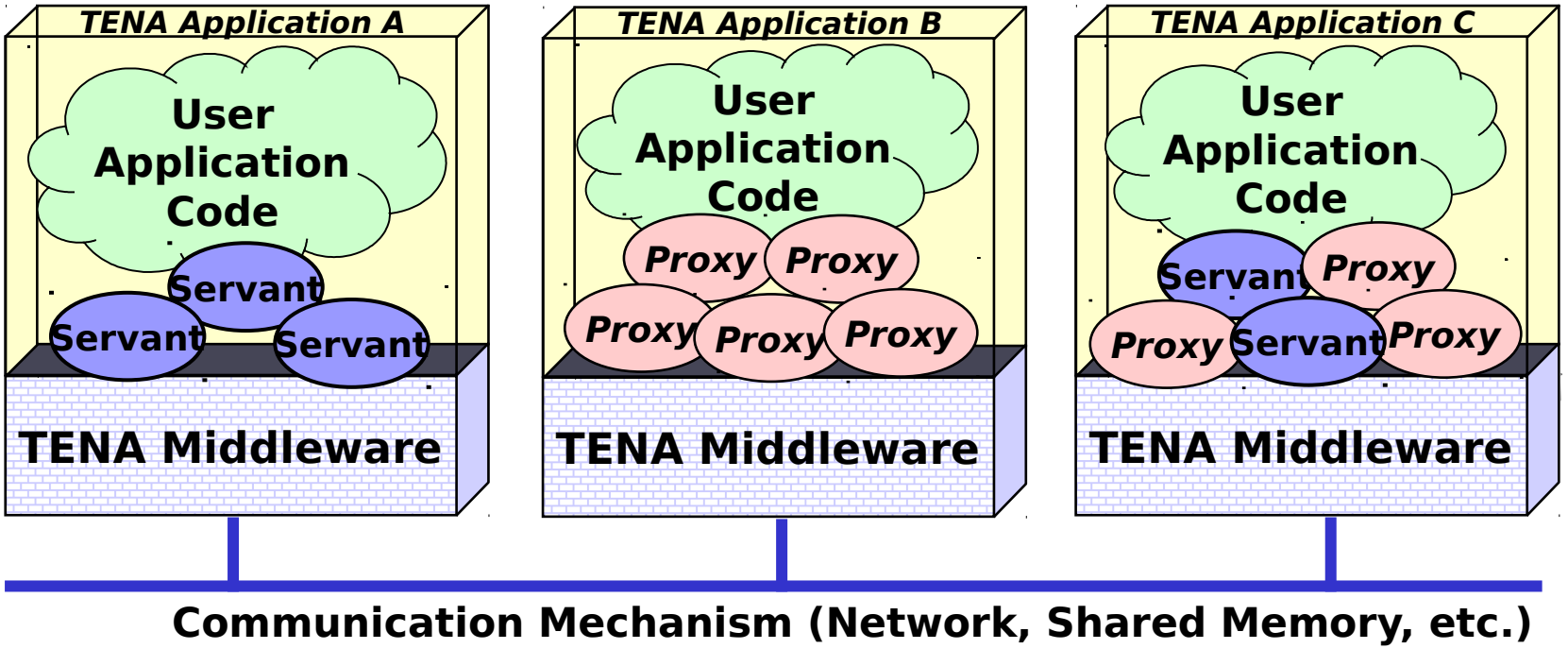
Logical Range Simple Example

TENA specifies an architecture for range resources participating in logical ranges



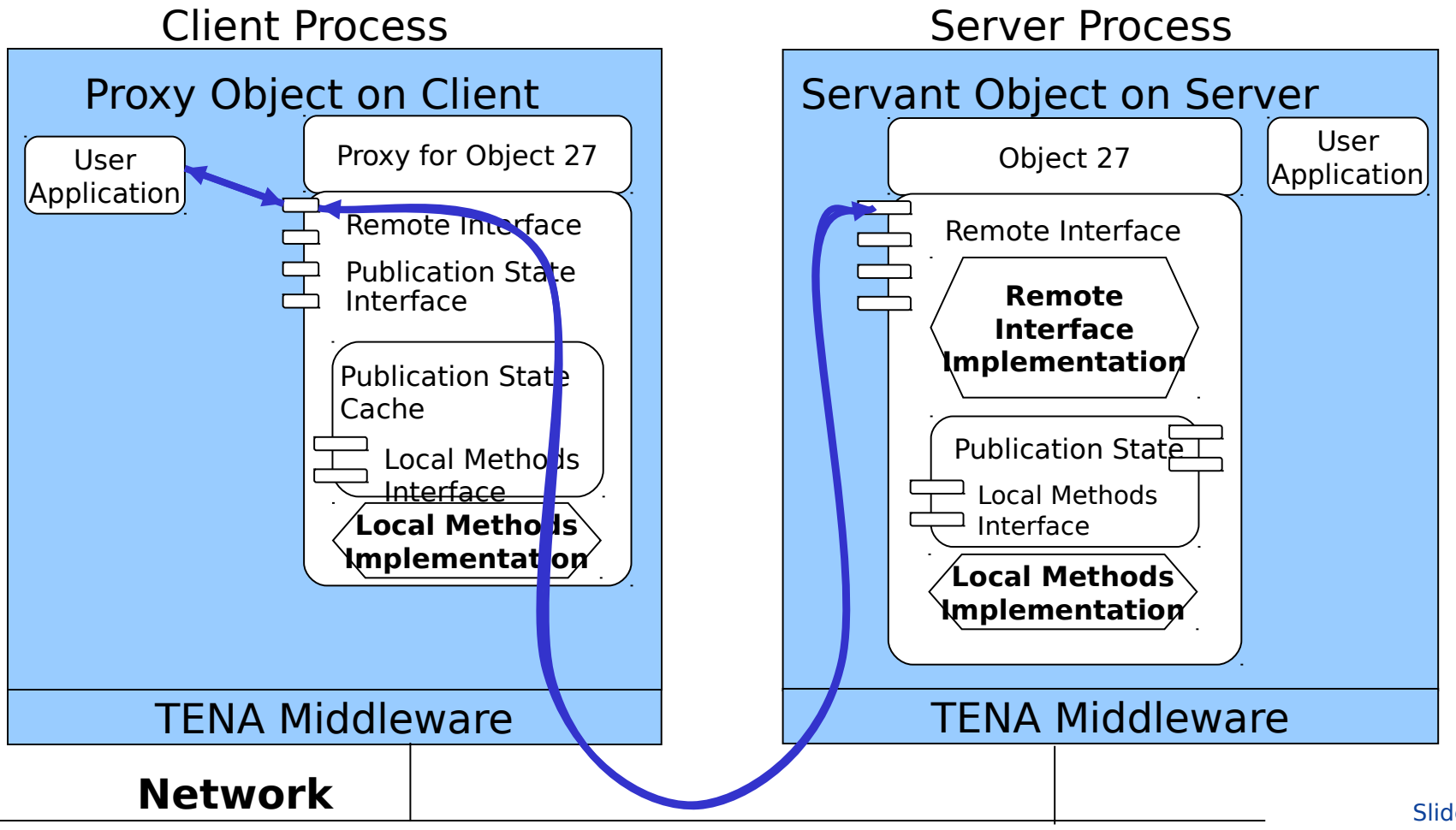
Logical Range Simple Example

- **TENA specifies a peer-to-peer architecture for logical ranges**
  - Applications can be both clients and servers simultaneously
  - In their role as servers, applications serve TENA objects called "servants"
  - In their role as clients, applications obtain "proxies," representing other applications' servants. Only servers can write to their servant objects' publication state
- **The TENA Middleware, the TENA objects, and the user's application code are compiled and linked together**



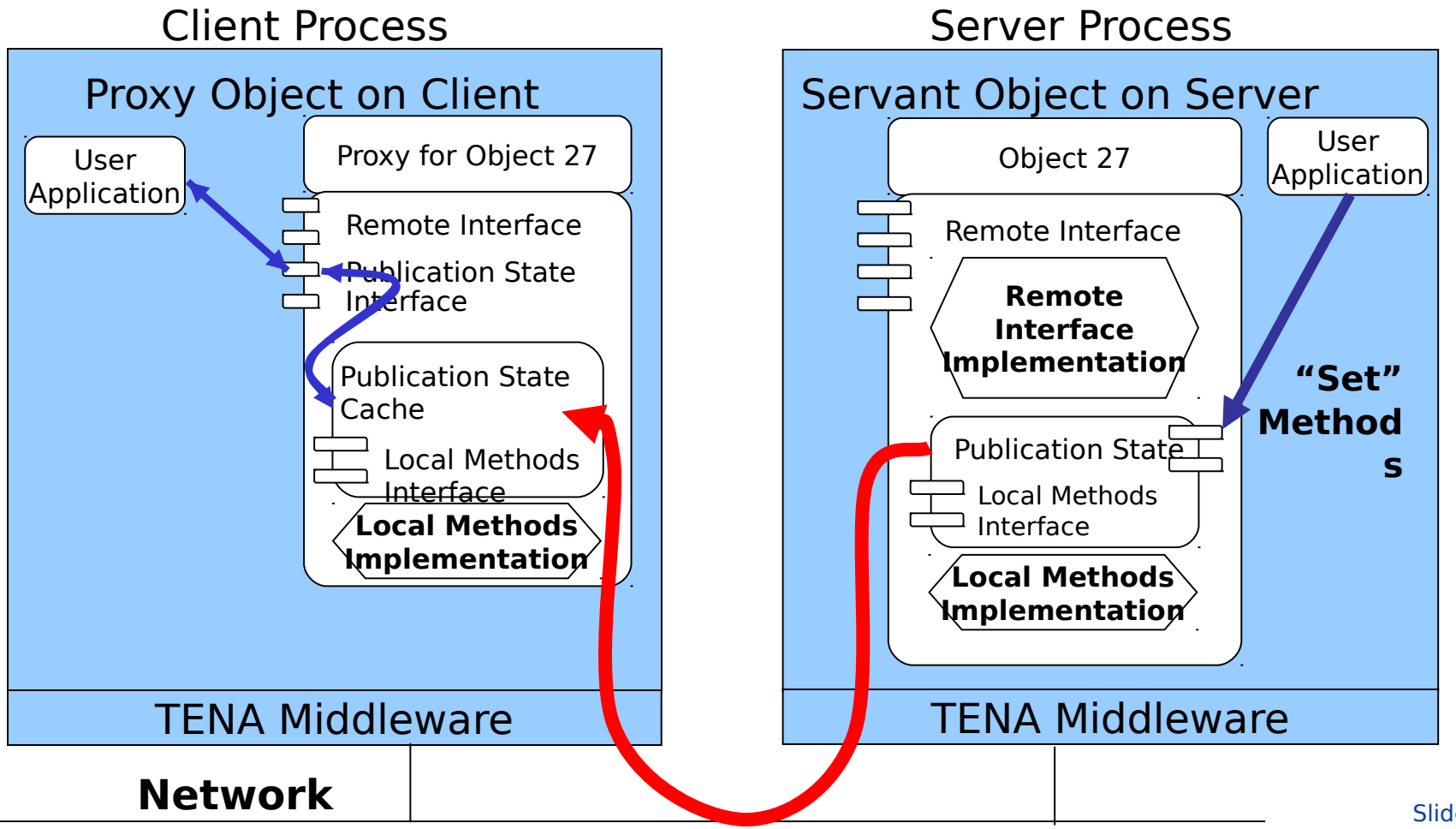
Clients and Proxies, Servers and Servants

- **Remote Method Invocation**



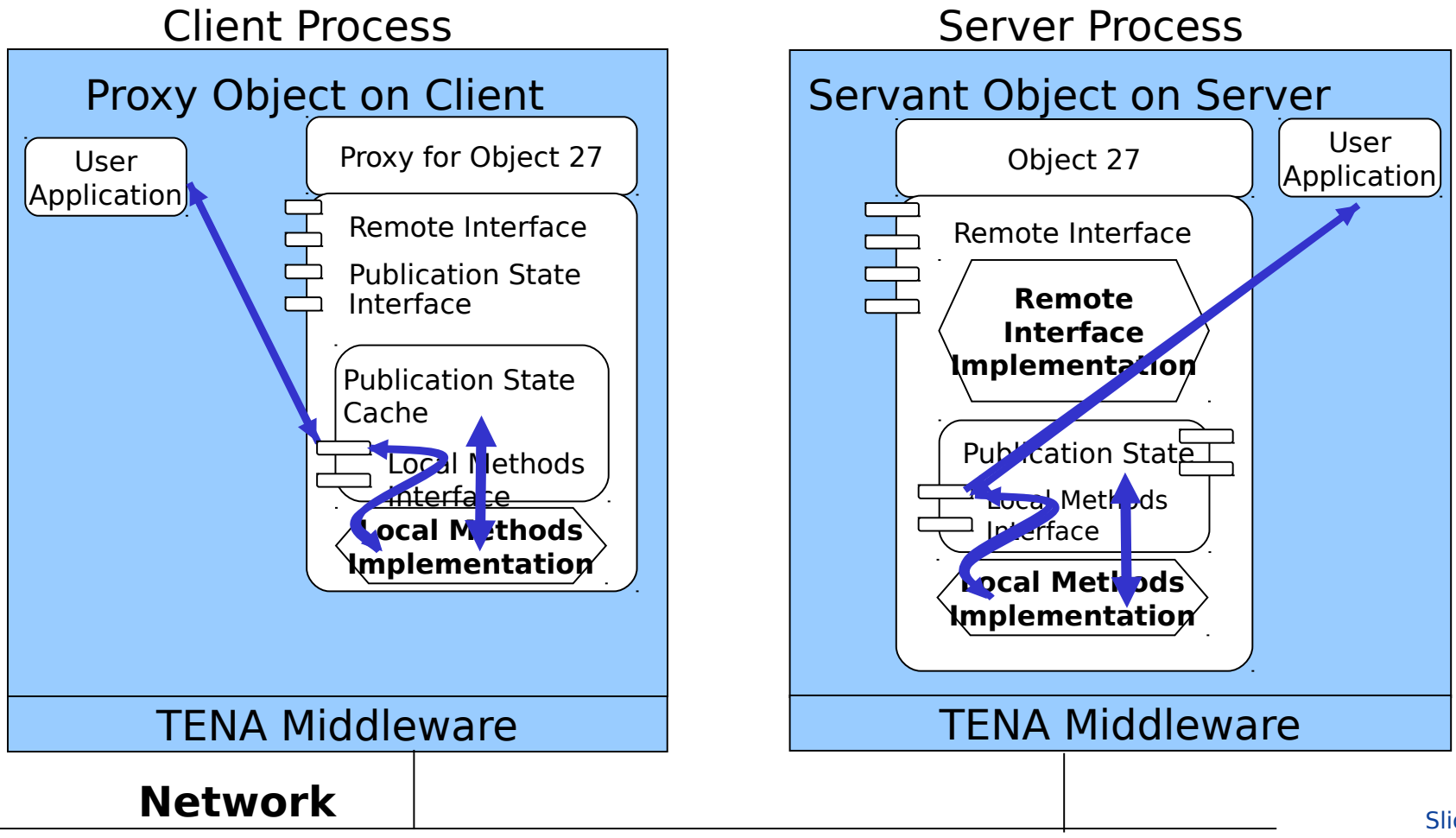
Clients and Proxies, Servers and Servants

- **Publication State Dissemination and Access**



Clients and Proxies, Servers and Servants

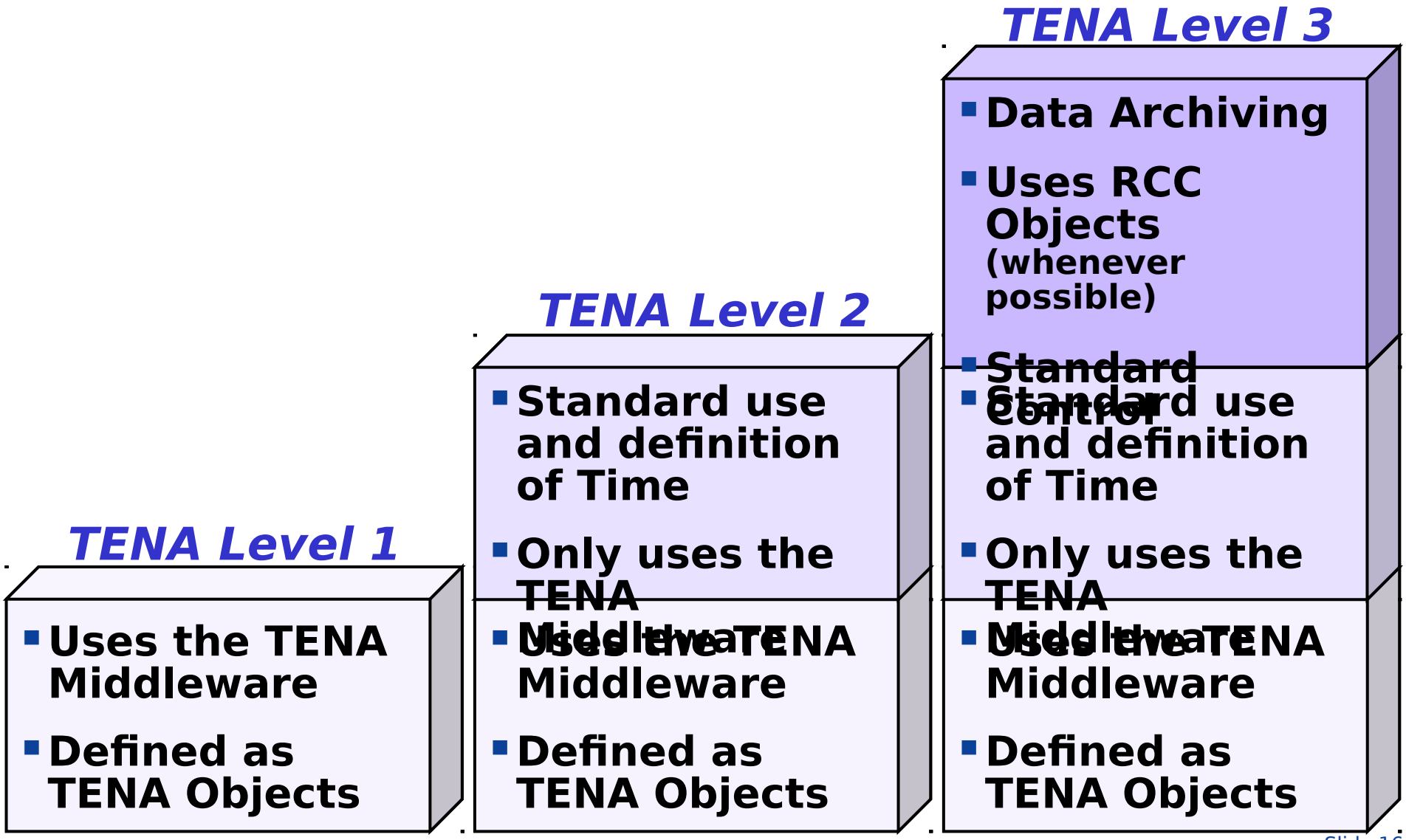
- **Local Methods used on both Client and Server**



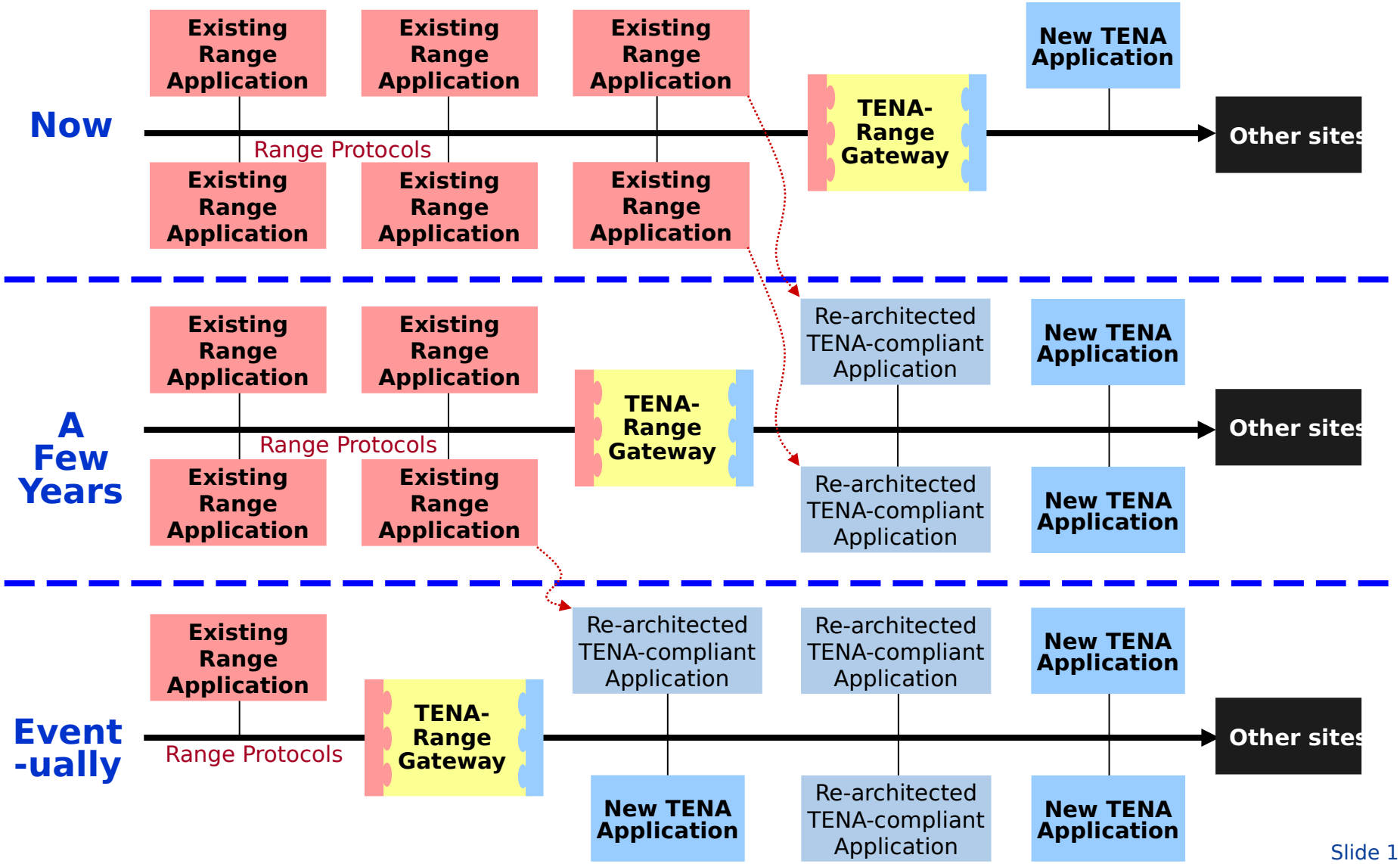
TENA Middleware Platform / Language Support

- **Release 4.0 Platform Support**
  - Windows 2000 sp4 with MSVC++ 7.0
  - Windows XP sp1 with MSVC++ 7.0
  - Linux Red Hat 8.0 (2.4.18 kernel) with gcc 3.2
  - Linux Red Hat 9.0 (2.4.20 kernel) with gcc 3.2.2
  - Sun Solaris 8 (SPARC) with gcc 3.2.3
- **Release 4.0 Language Support**
  - C++ support provided with current release
  - OCX (COM) wrapper developed by one of the TENA Users (RTTC)
  - Java wrapper methodology provided by one of the TENA Users (Eglin)
- **Soon**
  - Support for Windows MSVC++ 7.1 on XP and 2000
  - Support for SGI with both gcc and MIPSPro compilers
  - Support for VxWorks

TENA Compliancy Levels


TENA Level 3
Data Archiving
Uses RCC Objects (whenever possible)
Standard control
Standard use and definition of Time
Only uses the TENA Middleware
Uses the TENA Middleware
Defined as TENA Objects
TENA Level 2
Standard use and definition of Time
Only uses the TENA Middleware
Uses the TENA Middleware
Defined as TENA Objects
TENA Level 1
Uses the TENA Middleware
Defined as TENA Objects

Gradual Deployment of TENA



Range Integration in Millennium Challenge 2002 (MC02)

Blue Forces

- Ships
- Ground forces
- Aircraft

Opposing Forces

- Aircraft & air targets
- Ships

Nellis AFB
TENA Gateway

Land Range/China Lake
TENA Gateway

National Training Center/Ft. Irwin
TENA Gateway

Electronic Combat Range/China Lake
TENA Gateway

Sea Range/Point Mugu
TENA Gateway

US Marines/So. California Logistics Airfield

Joint Network

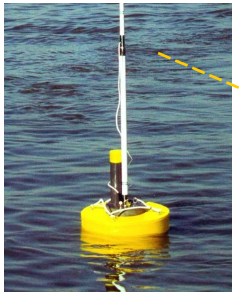
Joint Training, Analysis, and Simulation Cente

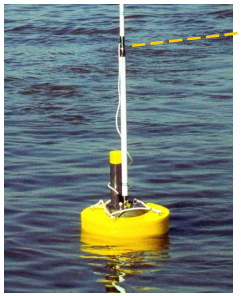
TENA Gateway
Integrating Software
Global Command & Control System

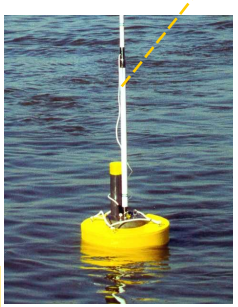
Model & Simulation Feed

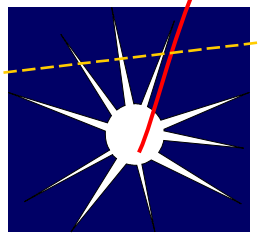
Command, Control, Communications, Computers, Intelligence Feed

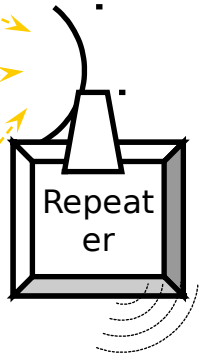
Gulf Range VAST/IMPASS

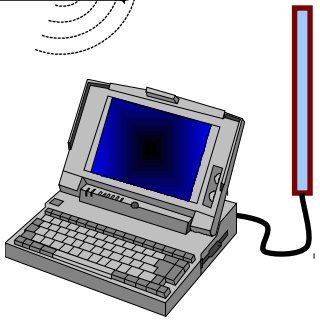




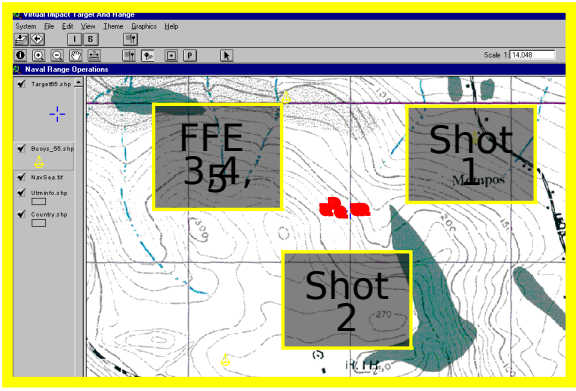








Shipboard Processing
Map Rendering
Virtual Target



Acoustic Processing
GPS
Communication Link

VAST/IMPASS Network Connectivity

Eglin Central Control Facility

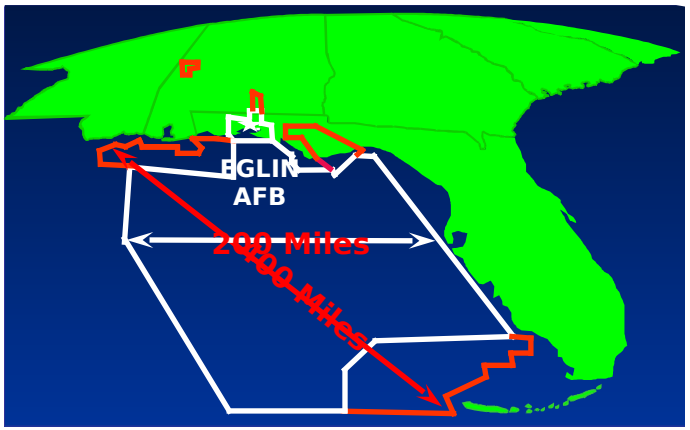
TENA on NIPRNET

CDSA Dam Neck, VA

TENA on Fiber

TENA on Microwave

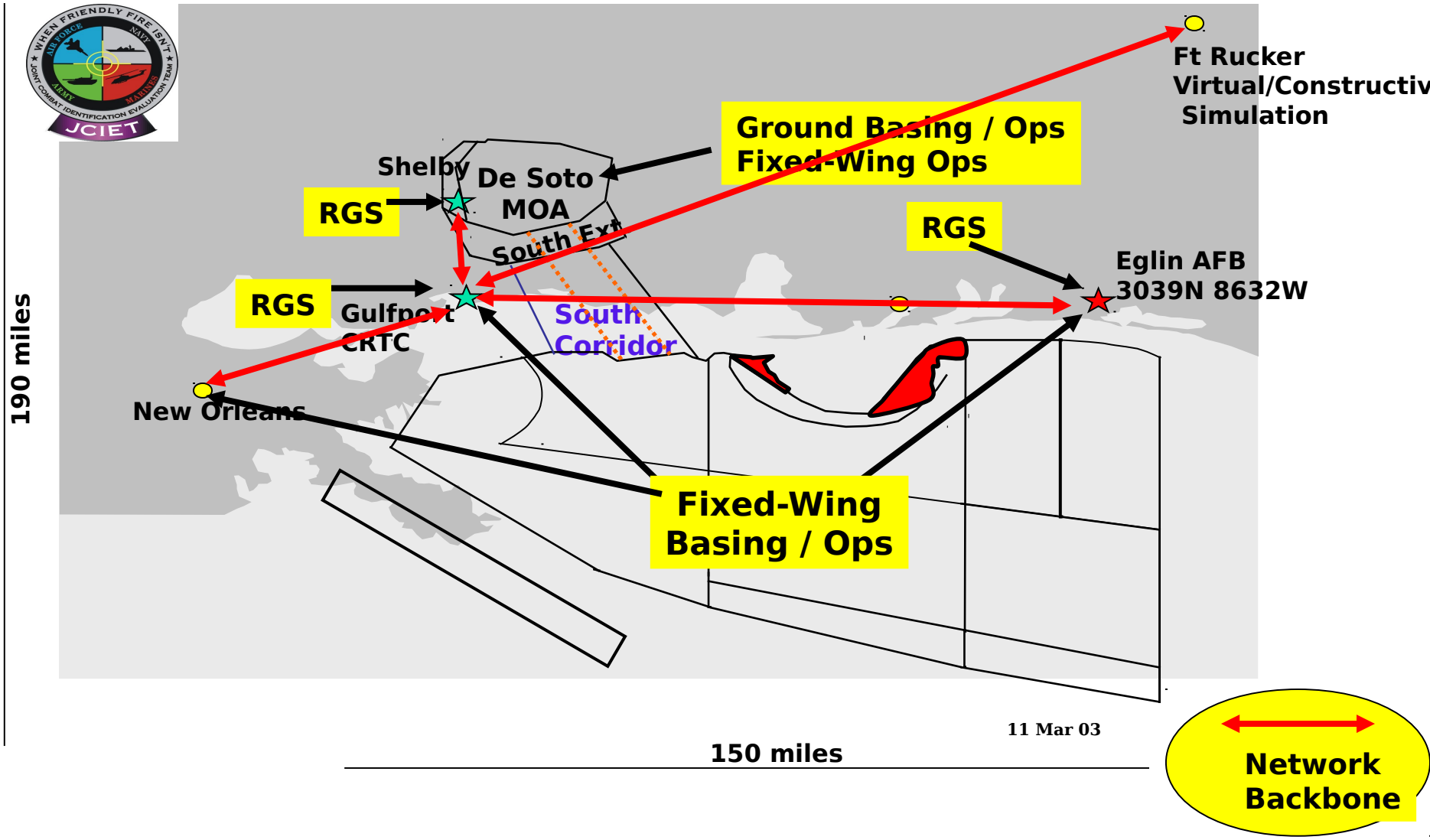
Eglin Range Site A-15



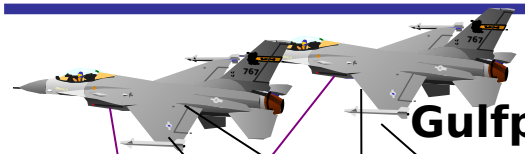
CSS Panama City, FL

JCIDEX03 – a JNTC Event

Geography, Facilities, and Network



JCIDEX 03 / TENA Activity



Live Infrastructure

Gulfport/Shelby/Camden MOA

ARDS GPS Pods

TACTS Pods

JTIDS Terminal

CRTC TACTS GND STN

CRTC LAN

ARDS GND STN

JTIDS TENA IF Gateway

TACTS TENA IF Gateway

ARDS TENA IF

Router

JCIET ADNET

Router

Router

Router

SA/AAR Display

- PCDS -

Camp Shelby MS

JECG Display

Rangeview

Ft. Rucker (opt)

SA/AAR Display

JECG Display

JECG Display

-Rangeview –

(Analysis

(AMO, TSPI, JTIDS,

Instrumentation)

Gulfport CRTC

Casualty Assessment Workstation

(A/G, G/G, A/A geo-pairing)

SA/AAR Display

- PCDS -

(TSPI)

Eglin AFB

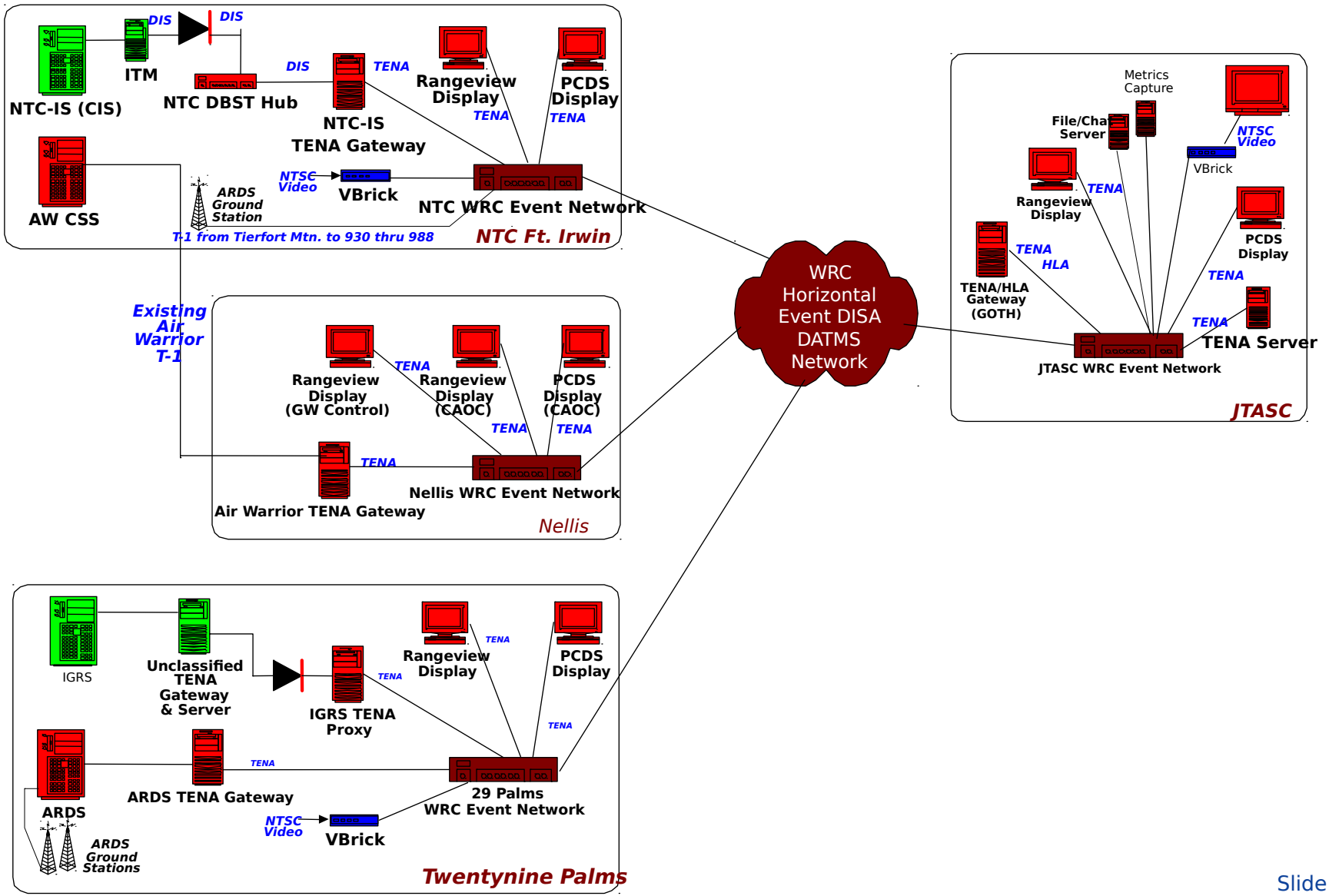
TENA Display

Rangeview

SA/AAR Display

JNTC Horizontal Thrust Event – Jan 04

Range Integration & Instrumentation Solution



Architecture Management Team (TENA AMT)

- **System Engineers & Technical Leads for the <u>current</u> major stakeholders of TENA**
  - AAC, Eglin AFB FL
  - NUWC, Newport RI
  - RTTC, Huntsville AL
  - PMRF Synthetic Range
  - EPG, Fort Huachuca AZ
  - WSMR, White Sands NM
  - NAWC-AD, Pax River MD
  - Virtual Proving Ground (VPG)
  - Joint National Training Center (JNTC)
  - NAWC-WD, China Lake & Point Mugu CA
  - Common Training Instrumentation Architecture (CTIA)
  - National Unmanned Underwater Vehicle T&E Center (NUT
- **Design Decisions / Trade-offs / Status**
- **TENA Use Cases / Prototype Test Strategies**
- **Technical Exchanges of Lessons Learned**
- **Issues & Concerns Identification, Investigation, & Resolution**

Meetings every 4-8 weeks

Raytheon, Boeing, SAIC, APL, MIT LL, JITC, DMSO, NRL, & ATC also attend & participate

Key Elements of TENA Revisited

- **TENA lowers the cost to integrate systems together**
  - Some systems made TENA-compliant <$20K for MC-02
- **TENA decreases the time to integrate systems together**
  - Auto-code generator generated 50K+ SLOC in a few hours from a 4 pg interface definition document
  - Legacy display system made TENA-compliant in 4.5 days for MC-02
  - Hydrophone instrumentation system made TENA-complaint in 2 days
  - HLA-compliant display system gateway made TENA-complaint in 1 day
- **TENA lowers the cost to reuse systems in future events**
  - Examples include VAST/IMPASS reusing pre-existing TENA capability
  - Will be better realized in future JNTC events
- **TENA improves flexibility of integrating systems together**
  - Range applications can be optimally configured for the particular test event

Key Elements of TENA Revisited (cont.)

- **TENA improves reliability of integrating systems together**
  - Auto-code generator ensures that every system has same baseline of source code
  - Standard, validated algorithms (such as coordinate translations or unit conversions) can be embedded in TENA rather than burden software applications of managing and performing translations
  - TENA Middleware performs data marshalling/demarshalling rather than burden software applications
- **TENA eases Deployment at the DoD Ranges**
  - TENA can be deployed gradually (system by system) rather than requiring all systems be redesigned
  - Providing on-site training at a number of ranges
- **TENA has a process to follow for sustainment/improvement**
  - Leveraged CTTRA workshops and the Architecture Management Team (AMT)
  - Established on-line User Help Desk system to capture feedback from TENA users
  - Pursuing RCC standards, and investigating OMG standards
  - Working with T&E CTTRAP to determine TENA policy among Services

Summary of What We Have

An Architecture for Ranges, Facilities, and Simulations to Interoperate, to be Reused, to be Composed into greater capabilities

- **Working Implementations of the Architecture**
  - **TENA Middleware currently works on Windows, Linux, and Sun**
- **A Process to Develop and Expand the Architecture**
  - **CTTRA Workshops, AMT Meetings, and RCC Coordination**
- **A Technical Strategy to Deploy the Architecture**
  - **Gateways provide interim solutions as TENA interfaces**
- **A Definition of Compliancy**
  - **Levels of compliancy to enhance communication among systems engineers and investment decision makers**

Important Contact Information

- **FI Program Web site, links to Middleware, help desk:**
  http://www.fi2010.org
- **Get the TENA 2002 Document:**
  http://www.fi2010.org/documents/tena2002.pdf
- **FI 2010 Program Topics:**
  fipmo@jcs.mil
- **Questions, comments, feedback about the TENA architecture or the TENA Middleware:**
  TENA-feedback@fi2010.org
- **TENA user community:**
  TENA-users@fi2010.org
- **TENA Object Model technical team:**
  TENA-om-team@fi2010.org